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N.A.A.S.

Quarterly Review

No. 22

Winter 1953

COMMONWEALTH MYCOLOGICAL INSTITUTE
1 JAN 1954

LONDON: PUBLISHED FOR THE MINISTRY OF AGRICULTURE AND FISHERIES BY HER MAJESTY'S STATIONERY OFFICE

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N.A.A.S.

QUARTERLY REVIEW

THE JOURNAL OF THE NATIONAL AGRICULTURAL ADVISORY SERVICE

No. 22 Winter 1953

Single copies price 1s. 6d. (1s. 7½d. by post). Annual Subscription 6s. 6d., including postage. SALE INQUIRIES should be addressed to the publishers at any of the addresses overleaf. EDITORIAL COMMUNICATIONS should be addressed to the Editor, N.A.A.S. Quarterly Review, Ministry of Agriculture and Fisheries, 3 Whitehall Place, London, S.W.1.

CONTENTS

ARTICLES Page

Polyploidy and Plant Breeding .. .. *G. D. H. Bell* 47

Infertility in Cattle. II. Functional Infertility .. *J. G. Wilson* 54

Farm Management and the Farm Management Handbook *Arthur Jones* 60

ABSTRACTS

Animal Breeding 65

Soils 68

Crop Husbandry 72

Machinery 74

Fruit 77

Nutrition of Horticultural Crops 78

Dairy Husbandry 80

Entomology 83

Virology 85

PROVINCIAL NOTE

Ley Farming on the Keuper Marl *J. W. Patterson and W. B. Mercer* 88

LONDON: HER MAJESTY'S STATIONERY OFFICE: 1953

ABSTRACTORS

AGRICULTURE

A. W. Stableforth, D.Sc., M.R.C.V.S., D.V.S.M. ... ... *Animal Health**
H. P. Donald, D.Sc., Ph.D., F.R.S.E. ... ... *Animal Breeding*
S. M. Boden, B.Sc., A.R.I.C. ... ... *Animal Nutrition**
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T. E. Williams, B.Sc. ... ... *Herbage**
D. H. Robinson, B.Sc., Ph.D., N.D.A. ... ... *Crop Husbandry*
C. Culpin, M.A. ... ... *Machinery*

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E. Skillman, B.Sc., N.D.H. ... ... *Glasshouse Crops**
Professor R. H. Stoughton, D.Sc., A.R.C.S.... *Flowers and Soilless Culture**
William Plant, B.Sc.(Hort.), Ph.D., N.D.H. *Nutrition of Horticultural Crops*
E. J. Winter, M.Sc. ... ... *Vegetable Crops**

GENETICS

J. L. Fyfe, M.Sc. ... ... *Crops and Plant Breeding**

DAIRYING

A. T. R. Mattick, B.Sc., Ph.D. ... ... *Dairy Bacteriology**
A. S. Foot, M.Sc. ... ... *Dairy Husbandry*

POULTRY

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ARTICLES

POLYPLOIDY AND PLANT BREEDING

G. D. H. Bell

Plant Breeding Institute, Cambridge

It is now over fifteen years since the detailed action of colchicine in producing polyploid tissues in higher plants was first observed, although there had been earlier work on artificial polyploids in seaweeds and other plants. Since this first work, many other chemical substances have been tried to bring about the doubling of the number of chromosomes, and although some have given success, none has really proved to be so generally effective and convenient to use as colchicine. This alkaloid drug has now been tried on a great range of plants, and, in spite of its relatively high cost, is now used more generally than any other chemical substance.

The intensive study of artificially-induced polyploids in cultivated plants has been the vogue for the last ten years and is being prosecuted widely at the moment. It is stimulated by the knowledge that about half the higher plants so far examined are polyploids which have arisen naturally and spontaneously. In other words, polyploidy is one of the widely occurring natural phenomena by which variation arises and evolution proceeds. Of even greater significance to the breeder is the fact that in cultivated plants, both agricultural and horticultural, there are examples of the extreme importance of polyploidy in the natural evolution of the most valuable forms available to the grower, for example, wheat, oats, potatoes and brassicas. But it is important to appreciate that some of the most variable and successful cultivated crop plants (barley, for instance) do not show any natural incidence of polyploidy.

It is only natural for breeders to experiment with a technique which has proved so fruitful in nature when a convenient method has been discovered, but it is necessary to be quite clear about the significance of polyploidy and its generally associated consequences and effects before attempting to consider in detail any achievements in breeding work. First, a distinction must be drawn between the two main types of polyploidy—autopolyploidy and allopolyploidy. In autopolyploidy the chromosomes are multiplied in an individual plant which is not the result of a wide hybridization, such as between two species, but a normally fertile individual which may be the result of self- or cross-fertilization within one species. Allopolyploidy, however, is the doubling of chromosomes in an individual resulting from a species of genus cross, or such combination as normally produces sterile hybrids. As a result of the chromosome doubling the individual becomes sexually fertile to varying degrees according to the hybrid. Such

hybrid polyploids are often called amphidiploids, a more or less alternative term to allopolyploid.

Secondly, what are the results most likely to be expected from the artificial doubling of the chromosome number in any individual? Although, obviously, a similar type of effect would be expected to that observed in naturally occurring polyploids in other species—otherwise there would be little point in trying to emulate nature—it must be emphasized that the successful and valuable natural polyploids are the result of natural selection over many thousands of years, accompanied, in the case of cultivated plants, by selection under cultivation. Therefore, although we may expect general trends and anticipate certain character expressions, it is impossible to prophesy accurately what will happen when polyploidy is induced artificially in any individual. Nor should it be anticipated that a valuable new plant of economic worth that could be taken directly into cultivation, particularly for agricultural purposes, is likely to be created. The most prudent approach to this experimental technique in breeding is that it can create new genetic material on which to work, thereby providing wider opportunities for improvement along lines that would not otherwise be available for the breeder.

Far-reaching Effects of Polyploidy

Nevertheless, there are certain generalizations possible concerning the expectations from artificially-induced polyploids. Thus it is clear that the approach to allopolyploidy is quite different from that to autopolyploidy. The hybrid polyploid (allopolyploid or amphidiploid) is normally produced experimentally in order to combine certain characters, or introduce one valuable character, which would be impossible to achieve otherwise because the unrelated nature of the parents would prevent fertile offspring resulting from the union. For example, artificial allopolyploidy has made it possible to hybridize successfully not only certain species of wheat with different chromosome numbers, but also wheat with rye, and wheat with certain species of couch-grass (*Agropyron*) and goat-grass (*Aegilops*) which belong to different genera from wheat. Artificial allopolyploidy consequently seeks primarily to effect successful union of difficult parental combinations, but the all-important considerations which have to be taken into account are the kind of individual that will result from any such combination, and how it will behave from generation to generation. At one time it was thought that all artificial amphidiploids would be completely fertile and genetically stable. It is now known that fertility differs from one amphidiploid to another, while there may be considerable genetic instability after the first generation—giving some resemblance to ordinary hybrid populations which segregate in the second and subsequent generations. It is not necessarily a defect of amphidiploids to be genetically unstable in this way: indeed, such behaviour offers unexpected and new possibilities in the exploitation of this type of hybrid.

In contrast to the sexual fertility of amphidiploids, which is normally inversely proportional to the fertility of the hybrids from which they are derived, it is usual for autopolyploids to show reduced fertility compared with the forms from which they have been produced. In virtually all cases, this lowered sexual fertility of autopolyploids is a serious defect, particularly in plants which, like cereals, are grown for seed production; although in many instances this is offset to some extent by each seed or grain being larger than in the corresponding diploid with its undoubled number of chromosomes. It is in this increased size of individual organs that the most characteristic effects of autopolyploidy are seen, such polyploid plants having larger cells in their tissues. Thus larger flower parts, even to the pollen grains, are usual; leaves may be wider, thicker, of a richer green and with stouter stalks; fruits may have changed conformation, as also may the roots of such crops as sugar beet, the general tendency being to greater stoutness and shortness. Such morphological changes may have the greatest significance when the plant is grown specifically for the part which shows a modification of this kind—for example, in an ornamental plant grown for its flowers, a vegetable or field crop grown for its leafy parts, or any crop whose economic importance depends on a special vegetative storage organ, such as swollen buds or tap roots. It is for this reason that some workers consider that the most promising subjects among agricultural plants for exploiting artificial autopolyploidy are those crops that are grown primarily for their vegetative parts, as opposed to the seed or grain.

There may, however, be far-reaching effects of polyploidy which are not easily observable in these changed attributes of the various plant organs; effects which may, nevertheless, be directly or indirectly associated with a visual character, such as leaf conformation. These effects can be seen in a changed metabolism and physiology of a plant which, in consequence, may show new attributes that are of importance in the cultivation or utilization of the crop. It has been noted, for example, that in some cases autopolyploids differ from their " parental " diploids in the vigour and rate of their development, being slower, not only in the earlier vegetative stages, but also in maturing. This fundamental change in such an important character may or may not be associated with other characters, but it is commonly found that the chemical composition, including the amount of dry matter, of the plant tissues has been affected. It is, therefore, not surprising that there is evidence which indicates that the mineral nutrition of an autopolyploid is different from the diploid, and that a polyploid strain of a crop may require different treatment in the field from the point of view of fertilizer dressings if the best results are to be obtained. Finally, as might also be expected, it has been claimed that fundamental attributes, such as drought resistance and hardiness, are also affected. These attributes are associated with certain morphological characters as well as the physiology of the plant, so it is not surprising that to changed morphological characters of the leaves and an altered metabolism must

be added a different response to water relations and temperature fluctuations.

Autopolyploidy Attracts the Greatest Attention

In view of the very wide range of effects on the morphology and physiology of the plant, it is to be expected that, as the technique of artificial autopolyploid induction is more straightforward than that of allopolyploid induction, more work has been done with the former than the latter. It must also be remembered that the opportunities for the application of the more speculative autopolyploidy are much greater because there are more potential subjects to study than for allopolyploidy, which requires very special conditions and relationships of the parental material for the initial hybridizing. Consequently, amphidiploid induction as a means of plant improvement, in addition to being conducted on a much more limited scale, tends to be restricted to carefully devised long-term breeding programmes with well-considered and definite objectives. It is much simpler to treat random or selected individual plants with colchicine as a speculative gesture—and attain the possible rewards more easily—than to collect and handle material with the complications of sexual incompatibilities that is the necessary concomitant of artificial allopolyploid induction.

In the light of the above considerations it is to be expected that a far wider range of plants should have been investigated for the possibilities of artificial autopolyploids than of artificial allopolyploids. It is also true that, with one or two major exceptions, the practical achievements from the breeding point of view are confined to the autopolyploids, which must continue to attract the greatest attention and give the quickest returns in terms of new forms of immediate economic value. There are, in consequence, examples from many parts of the world of work of varying success on autopolyploids using an extraordinarily wide range of crops. There are relatively few examples, however, of any such plants having yet achieved economic or practical significance by being taken into cultivation.

Cereals

Among the more important agricultural plants the most advanced work on autopolyploid arable crops has been on rye—in Holland, Sweden and other European countries where this crop is widely grown. Tetraploid rye has been produced quite extensively ; various tests have shown that improvement in grain size (as much as 50 per cent larger) and, in some cases, in baking quality, are offset by such disadvantages as reduced grain setting, ear size, ear toughness and tillering. Nevertheless, improved tetraploid forms with a higher germination capacity in the field have been produced. Largely because of their better baking quality due to a higher protein percentage, these are being propagated with a view to putting on the market as a commercially useful crop. One strain was actually marketed in Sweden in 1951.

The only other cereal crop of temperate regions that lends itself to autotetraploidy is barley, and here again larger grain is characteristic, though in France some tetraploids are said to be shorter in the straw. In spite of the useful attributes, no tetraploid barley has reached the commercial stage, although the stronger straw and coarser grain does suggest some possibility for the production of feed barleys. Unlike rye, however, where the best tetraploid forms have been claimed to outyield the diploid forms by as much as 15 per cent, the tetraploid barleys are lower yielders. In tropical zones, investigations on the all-important staple cereal—rice—have mostly been disappointing, but recent work in India has been claimed to have resulted in tetraploid forms with increased yield but later flowering.

Beet

Outside the cereal crops the most intensive study, and probably the greatest advance, has been made on sugar beet and fodder beet. These crops are naturally cross-pollinating, and consequently each plant treated is not pure bred ; it is usually the product of cross-pollination by another plant of the same variety, as in rye.

The interesting thing about autopolyploid sugar beet is that, in spite of the fact that there are polyploid varieties which have been named and put on the market in Denmark and Germany, there is a singular lack of agreement on the virtues of polyploid forms compared with diploid forms. This is undoubtedly due to the genetically distinct material that has been used to produce the polyploids, and also because the polyploid material in some cases is said to be primarily tetraploid, in other cases it is said to be primarily triploid, while in all cases there appears to be an unknown proportion of diploid plants. There is, in fact, considerable controversy over whether the breeder should concentrate on the triploid or tetraploid chromosome number. Work in this country—including that at Cambridge, where the problem has been studied for some years—has not yet given the answer. Nevertheless, the effect of polyploidy on the sugar beet plant can be profound—germination rate, plant establishment, rate of development, leaf morphology, root conformation and seed ball characters being the characters more obviously affected. In addition, it is claimed that the response to Virus Yellows infection can be affected, while the net result on the production of sugar can be influenced by changes in the root weight or the sugar percentage. Increased sugar production per acre from polyploids has been claimed by increases in the expression of either of these characters, but it is important that some workers insist that it is only the triploid forms which show this improvement : the tetraploids, it is claimed, are actually inferior to the diploids.

Although it is certain that polyploid sugar beet offers considerable possibilities of improving the production of the sugar beet crop, there is still so much to explain and to learn from the confusing and conflicting reports that it is too early to say whether many of the claims made will stand the rigorous test of field cultivation on a commercial scale. There

is as much to do to learn how to exploit polyploid sugar beet efficiently and scientifically as there is to start breeding a new strain of sugar beet *de novo* : polyploidy is not necessarily a short cut to improvement in any crop.

Other Crops

There are many more agricultural plants which are in the process of being studied intensively along these accepted lines of induced polyploidy. In herbage plants, timothy grass, white clover, red clover, alsike clover and lucerne are well represented, but it seems that it is only in alsike and red clover that there are positive achievements in the form of more productive strains available to the grower. Other crops which have yielded interesting, if not always positive, results are potatoes, flax, buckwheat, turnips, white mustard and turnip rape ; among garden and vegetable crops, tomatoes, cucumbers, radishes, spinach, beetroot and a wide range of brassicas are being studied. The story is very similar in most of these plants—increase of seed size but lower seed production in those grown for their seed, and more robust but often slower vegetative growth in those being grown for vegetative parts. In this connection, too, colchicined potatoes are said to have given substantial increases in yield, but with a high proportion of ugly tubers suitable only for industrial purposes.

It is of interest that the only artificial autotetraploid strain of any edible plant produced in this country resulting from this sort of work is a watercress, produced at Cambridge and now in the hands of growers. But the possibilities of improvement in other characters cannot be ignored when one considers claims of greater resistance to tumefaction on the part of a tetraploid tomato in France, and of greater resistance to drought and insect attack of tetraploid egg plants in Japan. Finally, the possibility of using autotetraploidy as a means of creating useful breeding material cannot be ignored, for example, when it is desired to hybridize a diploid species with a tetraploid species. By doubling the chromosome number of the diploid species first, the chances of successful hybridization are much increased as has been found when it was desired to hybridize a wild diploid species of *Solanum*, which was resistant to late blight and Colorado beetle, with the cultivated potato, which is tetraploid.

Use of Allopolyploids in Plant Breeding

Now the question of the use of artificially-induced allopolyploids may be considered in relation to its impact on plant breeding. It is known that such valuable crops as wheat, oats, sugar cane and cotton are natural allopolyploids, and, in some cases, there is very good evidence of the identity of the parents. Hence, under experimental conditions, a very good duplication of what happened naturally many thousands of years ago has been possible : a higher chromosome wheat species has been synthesized very like an old-established species.

It is therefore tempting to see what entirely new forms of cultivated plants can be produced experimentally, and also to try to combine

certain valuable characters, or obtain attributes like disease resistance, from previously inaccessible sources. At Cambridge, for example, well over a hundred allopolyploids (amphidiploids) have been obtained by hybridizing different species of wheat, and by hybridizing wheat with rye, couch-grass and goat-grass species. Some of the wheat species amphidiploids have already been used for hybridization with ordinary bread wheat varieties, as also have the intergeneric amphidiploids ; while all of the amphidiploids are being carefully analysed for their disease reactions where it is known that one or both of the parents is very resistant. This collection of amphidiploids has been placed at the disposal of research workers in Canada in the hope that they may help in coping with a new strain of black stem rust in wheat, and useful sources of resistance appear possible. It is unlikely that that this type of amphidiploid will have any economic application other than for breeding purposes, but its detailed genetic and cytological study is providing valuable and interesting scientific knowledge.

The only amphidiploids involving what may be called the " wheat complex," which may have any great direct agricultural use, are the wheat × rye and wheat × couch-grass combinations, and some of these have already been used in other countries. The wheat × rye (*Triticale*) forms are particularly interesting, as the possibility of producing an entirely new cereal combining perhaps the grain quality characters of wheat with the hardiness and the capacity to grow on poor soils of rye. There are, however, a number of technical problems involved in this work, and after many years of research it is only recently that forms with yields of acceptable standards have been obtained. However, the valuable combinations of characters obtained so far and the fact that, in the later generations, promising wheat-like forms have appeared in certain crosses, make it essential to continue with the study of these hybrids. The wheat × couch-grass hybrids already appear to have had direct use, particularly in N. America, principally as range grasses for sowing dry land areas ; but the Russians have claimed from time to time to have evolved valuable annual and perennial wheats from such crosses.

It is a matter of some practical agricultural interest that, so far, probably the most promising allopolyploid material has been obtained in the grass family (*Gramineae*). In addition to the examples given above, there are accounts of research work on sugar cane to produce high-chromosome interspecies hybrids, while an interesting form called the Mandan rice-grass (a recently-observed, fertile amphidiploid occurring naturally) promises to be a valuable new forage grass in certain areas. Again, attempts are being made with oats to obtain useful interspecific amphidiploids to hybridize with cultivated varieties ; while various herbage grass genera, such as the brome grasses and the meadow grasses, appear to lend themselves to this sort of manipulation for the production of vigorous types with a wide range of adaptation. There are, however, outstanding examples of important developments in other groups of plants, such as the potato, where valuable interspecific

amphidiploids have been created for use in hybridizing with the cultivated plant. Improvement of the latex plant *Guayule* in the U.S.A., and also of tobacco, is being sought in this way.

An Extensive Range

It may be seen that the ramifications of polyploidy in plant breeding are very extensive at the present time. No specific mention has been made here of the very important work in this direction that is being done on forest trees—birch, alder, spruce, pine—in various countries, or on tree crops, such as stone fruits, coffee, Cinchona (quinine) and other medicinal trees, which are being studied for polyploid possibilites. And so with forest trees and tree crops, through a wide range of arable crops grown for many different purposes, to forage and herbage plants and vegetables. There is indeed a catholicity of taste for suitable subjects when one finishes at the other extreme with yeasts which produce giant colonies, show an increased rate of fermentation, but do not produce any more alcohol ! No one can feel that the possibilities of polyploidy in plant breeding are failing to receive a fair trial as far as representation is concerned. But quantity is by no means the most important criterion of research work. There is considerable danger that the mere unthinking multiplication of unsuitable material, inadequately studied, may hinder the considered development and the proper fulfilment of a most significant addition to plant breeding techniques.

INFERTILITY IN CATTLE

II. FUNCTIONAL INFERTILITY

J. G. Wilson

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Sir Thomas Dalling in the first article of this series [1] emphasized the economic importance of bovine infertility. He stressed the necessity for making sure that the herd sire is fertile before going on to consider the females, and pointed out that most of the female infertility is of a temporary rather than a permanent nature. He divided the causes of the female infertility into four categories : infections ; disturbances of the hormone regulation ; nutrition ; genetical causes. Sir Thomas then went on to deal with the first category—the various infectious diseases which can cause infertility.

In the three years that have elapsed since the publication of his article the first two infectious diseases mentioned by him (contagious

abortion and trichomoniasis) have greatly decreased in incidence. The reduction in the amount of contagious abortion is most probably due to the widespread use of the S.19 vaccine, while, in the case of the venereal disease trichomoniasis, it is most certainly due to the ever-increasing use of artificial insemination in place of the communal bull.

The third disease—*Vibrio foetus* infection or vibriosis—has come to the fore more and more in recent years, and some authorities consider it to be the most common cause of herd infertility in this country at present. Recent research at Weybridge has confirmed the suspicion that the disease is a venereal one, that is, it is transmitted by service only. A diagnostic method has been elaborated and methods of cure and control are being worked out.

In this article it is intended to group the second, third and fourth categories of causes, mentioned above, under the main heading of " Functional Infertility," because they appear to the writer to be inseparable in causing the non-infectious types of bovine infertility. Functional infertility, which is a type of mainly temporary infertility very often affecting whole herds at a time, has, in recent years, become more and more prevalent, and in the writer's experience it is now the commonest type of infertility. There are no very characteristic signs in this condition, but two main types can be found. In the first type a low state of ovarian function or ovarian hypoplasia occurs, with the ovaries sub-normal in size and the females having a tendency towards anoestrum, or failure to come in season, or exhibiting oestrum only at long intervals. Recent work [2, 3 and 4] has shown that the failure to breed in many apparently normal cows is due to early embryonic mortality. This may be a part of the same picture and be due to a low output of pituitary and ovarian hormones—which affect the descent of the fertilized ovum through the oviducts and the subsequent development and implantation in the uterine wall—or to the shedding of an " unripe " ovum predestined to an early death (although capable of being fertilized).

The second type shows a tendency towards delayed ovulation, failure of ovulation (with formation of follicular cysts) and the forming of atypical and cystic corpora lutea. This tendency indicates " luteal failure "—a low output of anterior pituitary luteinizing hormone (and consequently of ovarian progesterone). In the extreme forms, there may be typical " cystic ovary " cases exhibiting nymphomania or adrenal virilism (where the cow appears to change into a bull).

The above types of functional trouble are apparently due to endocrine dysfunctions and could be caused by *environmental* factors, such as nutritional and mineral deficiencies and imbalances, or by *hereditary tendencies*, but most probably by a combination of both. For example, some breeds are said to be more susceptible to functional infertility than others, and within the herd with functional infertility there are always some individuals (and sometimes " cow families ") that behave worse than the rest, and some that are not affected.

Hereditary Infertilities

Work in the U.S.A. [5] on the predictability of breeding efficiency of large numbers of cows and herds indicated that there was no marked widespread inheritance or repetition from year to year of infertility in dairy cows. Animals, which in a given year needed 1 service more per conception than the average for the group, needed only 0.1 services above the average in the next year; and only 9.3 per cent of problem herds were still problem herds the following year. On the other hand, 55 per cent of all cows and 54 per cent of all herds showed the same level of fertility in two consecutive years. Work in Sweden on the bull, using pairs of identical twins, indicated that the capacity for both sperm production and service seemed to be determined more by hereditary factors than by nutrition.

In the Swedish Highland breed a hereditary gonadal hypoplasia has been described [6] in which up to 17 per cent of the young bulls and heifers have been found to be completely sterile because of complete (both-sided) hypoplasia of the testicles or ovaries. In addition, an equal number of animals were found to be suffering from "partial and doubtful" hypoplasias (more commonly affecting the left ovary). These showed reduced fertility and appeared to be very sensitive in this respect to changes in the environment, especially as regards nutrition. Rigorous culling, particularly of bulls, is controlling the incidence of this condition in Sweden, and the occurrence of complete hypoplasia in heifers has now dropped to 9.5 per cent. A condition resembling this is sometimes seen in inbred families in certain breeds in this country.

The condition of cystic ovaries with nymphomania or adrenal virilism has also been studied in Sweden [7], and there are strong indications that there is a hereditary predisposition towards it. Mother and daughter have often been seen suffering from the condition in this country; a milder form, more amenable to treatment, is also frequently found in herds suffering from a temporary functional infertility, and it is probably associated with nutritional factors. A hereditary infertility was studied in a Jersey herd of an agricultural college in the U.S.A. [8], and the dysfunction appeared to be an inevitable early embryonic death due to an autosomal recessive genetic factor. A number of lethal factors with a recessive mode of inheritance have been described, which either produce a foetus incapable of normal life or result in early embryonic death, sometimes with foetal absorption; in multifoetal species this results in reduction of litter size.

Environment Conditions Affecting Fertility

Nutrition

The individual female suffering from a debilitating illness usually ceases to breed until she starts to recuperate. This may be an example of the "stress syndrome," whereby under stress the anterior pituitary ceases to produce the less essential hormones such as the growth and gonadotrophic hormones.

Heifers on a low plane of nutrition in winter (especially if the protein intake is low) usually go anoestrous and stop coming in season. The same thing can happen with adult cows, and many temporary herd infertilities can be ascribed to low food intake, especially of protein, which probably exerts a specific effect on the anterior pituitary. Medical evidence from the German concentration camps supports this theory. There it was found that a small protein intake over a short period was enough to restore normal function long before lost bodily condition was regained.

Mineral Deficiences and Imbalances

The hypothesis [9] has been put forward with much circumstantial and some direct evidence that if the lime : phosphate ratio of the diet is more than 2 : 1 or 1 : 2, and the intake of one of them is sub-standard, a functional infertility results. It has been suggested, again with some evidence, that the generally accepted standards for these elements in the maintenance and production rations, especially of phosphorus, are too low.

The writer [10] has had some confirmation of these theories in mineral feeding experiments and in the analysis of the rations of infertile herds in the field, but improvement in the fertility rate was obtained equally in the same sub-fertile herd by feeding either phosphate or a mixture of three trace elements, iodine, copper and manganese.

Trace Elements

Iodine deficiency has been said to produce infertility by depressing thyroid function. Thyroid dysfunction due to other causes, such as the excessive feeding of protein or of plants containing goitrogens, may also produce infertility. Thyroid dysfunction is said to cause a decreased androgen and oestrogen output by the respective gonads. Infertility has been associated with hypocuprosis by many writers [11]. It may be due to the general debility associated with copper deficiency, but suggestions that a functional infertility associated with ovulatory failure has been caused by manganese deficiency have not been proved (or disproved). Nevertheless, my experience suggests it may occasionally occur.

Deficiencies of these trace elements may be actual or may be conditioned by the excess in the diet of an element such as calcium, molybdenum or iron, which could interfere with the absorption and utilization of the trace element.

Vitamin Deficiencies

Vitamin A is necessary for the health of the epithelium lining the breeding passages ; the lack of it, it has been suggested, causes abortion in cattle and absorption of foetuses in sows. Experiments with rabbits have shown foetal absorption in does deficient in this vitamin [12].

Vitamin D may be a possible factor in functional infertility associated with lime and phosphate imbalances, especially in housed cattle in the winter [13].

Deficiency of vitamin E has also been said to cause male and female sterility, but this has never been proved in cattle. Such a vitamin deficiency conditioned by feeding unsaturated fats can cause a muscular dystrophy, and could render a bull impotent through partial paralysis of muscles of the hind legs and quarters. The apparent good effects of wheat germ oil in infertility cases may be due rather to its oestrogen, androgen and gonadotropic hormone content than to the presence of the vitamin.

Oestrogens

High oestrogen content of strains of subterranean clover in Australia (especially when soil is lacking in phosphate) has caused infertility and abortion in ewes. The oestrogen content of clovers and improved grasses has not been proved to cause any trouble among cattle and sheep in this country.

Heredity and Environment Inseparable

It will be seen from the foregoing that both hereditary and environmental factors can cause the same type of functional infertility by upsetting hormone balance. Apparently a specific deficiency does not produce its own particular symptoms of ovarian dysfunction, so the cause of a particular outbreak of herd functional infertility may be quite complex. It is, therefore, usually easier to get the herd back to breeding efficiency than to trace the exact environmental factor or factors which originally caused the trouble; and it is not unusual for an unbalanced herd of this type subsequently to experience other bouts of trouble, either of another type of functional infertility or of some other metabolic disorder. Recently, it has been shown [14] that susceptibility to infection by one of the organisms with which infertility may be associated—*Corynebacterium pyogenes*—is connected with a hormonal imbalance, a lack of oestrogen and excess of progesterone. This, in turn, may be due to an environmental factor. In the writer's experience, *C. pyogenes* infection is often associated with overfeeding of protein, and this might act by inducing hypothyroidism, with a consequent reduced oestrogen output.

In conclusion, no better advice on the prevention of functional infertility can be given than that contained in the recommendations of the session on animal nutrition and fertility of the Sixth International Congress of Animal Husbandry [15], held in Copenhagen in the summer of 1952. Briefly the conclusions they reached were:

1. To increase the output of any branch of animal production it is necessary to give due attention to a properly constituted ration to maintain satisfactory fertility.

2. Attention should be given to the fact that nutrition influences fertility through the hormone metabolism and through the supply of necessary nutrients to the foetus.

3. High yield and satisfactory fertility are compatible if the ration is correctly constituted.

4. Special attention should be given to: under-nourishment; prolonged over-nourishment; deficiency in proteins; deficiency in phosphorus, calcium, manganese, iron, cobalt, copper, and iodine, as well as in vitamins and other micro-elements. The influence of poisonous substances in feeds should also be considered.

5. Attention should be paid to high quality natural and concentrated feeds, which should especially be of high biological value. Correct application of fertilizers to fields producing forage crops, as well as proper harvesting, storing and preparation of the feed is primarily of great importance in this respect.

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FARM MANAGEMENT AND THE FARM MANAGEMENT HANDBOOK

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Before 1939 some of our farmers, judged by standards of capital invested in livestock, crops and equipment coupled with a small turnover of cash in the form of sales and purchases, could be considered more akin to the self-sufficient continental smallholder than to the entrepreneurs they have since become. Further, the Norfolk Four-Course Rotation, which had been the mainstay of our agricultural system through all manner of crises for 200 years, could not, without drastic modification, meet the economic conditions which farmers faced after the First World War. Survival of both the system and the farmer presupposed eighteenth and nineteenth century conditions of internal and external trade. Generally speaking, the farmer could successfully meet this threat to his living in two ways: in the first place by cutting down all but necessary expenses and almost literally by living on the produce of his own soil, or, alternatively, by following a more flexible rotation and by adopting new methods and systems which might mean considerable intensification of production in one or more enterprises. Many farmers who refused to adopt either one or other of these courses were driven out of farming, not because they were bad farmers but because they were unwilling to meet new conditions.

This is not the place to discuss in detail the pattern of farming which developed between the wars, except, perhaps, to say that the essence of any material success which was possible under ruthless economic conditions was based on the economic efficiency with which farmers could convert raw materials into finished products at a profit and a

price the consumer could pay. In other words, tradition and custom had to be abandoned and new methods and more flexible systems adopted.

In the middle of these changes in practice and theory came the war, when such questions as production costs, allocation of resources, or the right combination of enterprises, appeared to be of relatively minor significance. Under war conditions obviously the main objective must be maximum production within the limit of the total physical resources available to agriculture. Prices were fixed at a level that would provide sufficient incentive to secure high production from the majority of farms, irrespective of their type or situation. This policy was successful and no one today questions the contribution that farmers made to the tremendous problem of feeding fifty million people in most abnormal circumstances. We are not, however, living under those artificial and strained conditions any longer and, apart altogether from the declared policy of the Government to free the economy of the country, the return to peace-time conditions is bound, sooner or later, to demand some adjustment in our approach to food production. It is true that the serious problem of our balance of payments and the uncertainty of world food supplies are still with us. It is, however, equally true that the overall economic situation is no longer compatible with a policy of production at any cost.

Technical Advice Married to Economy

From now on high production at any cost cannot possibly be justified. We shall have to think rather in terms of higher production at a lower cost—an approach by farmers and ourselves as an Advisory Service which demands not only the offer and use of advanced technical advice but a much clearer and informed appreciation of the economic implications involved. Even today on the poorer types of farm, sound technical advice can be synonymous with sound economic advice. In other cases technical advice alone is no longer adequate if the country is to secure the best results from the resources devoted to agriculture, and farmers as well as consumers are to be satisfied.

The time has now come in the development of agricultural education and advisory work when the general agricultural officer, or, indeed, any advisory officer, must give increasing thought to the economic consequences of any advice he gives. This is not to say that technical advice on liming and manuring, seeds mixtures, cereal varieties and many other questions is no longer important ; in fact, it would be true to say that the need is greater than ever before. What has changed—and it is in this connection that management comes to the fore—is the way in which technical advice is given and related to the economy of the farm as a whole.

No one will deny the need for *increased* food production, but *maximum* production irrespective of financial return to the producer and cost to the consumer can no longer be regarded as an end in itself. Greater

efficiency of the individual farmer is the only answer to the problem of getting higher output at lower costs. The adviser must recognize from the very beginning the effect any suggested course of action will have on the overall farm economy. Any concentrated effort in one single enterprise without reference to the remainder can have an unbalancing influence on the farm economy in general, and the farmer's income in particular. Farm management advice has, therefore, a co-ordinating function to perform. It should weld together the wide and proved technical knowledge with the economic principles that govern efficiency. This approach directly implies the closest co-operation between the technical officer on the one hand and the economist on the other, so that the relevant technical and economic aspects will be considered in the plans or advice offered to the farmer. In this connection, I would like to refer to the *Farm Management Handbook*, which is bound to have a significant influence on the extent and type of farm management advisory work within the N.A.A.S.

Using the Handbook

May I say at the outset how much we as an Advisory Service owe to the Economics Division of the Ministry and the Provincial Agricultural Economics Departments of the Universities for the preparation and publication of this invaluable manual. However, the handbook in itself is not the answer to all the problems met in the field, and the data on standards of production and efficiency are by no means final and unchangeable, It is first and foremost a guide to the factors, and combination of factors, that determine a successful or unsuccessful enterprise, and, as such it will help the advisory officer to diagnose weaknesses in organization which otherwise would be obscure and difficult to assess.

To appreciate the significance of farm management advice and the use that can be made of the handbook, let us consider the position of our farmer-client. Generally speaking, he is seeking the best and most economic system of operating his farm to secure the highest net income for himself and his family. In formulating his plan against, say, a background of falling prices, he may consider *reducing costs*, which could result in the level of production remaining the same or being reduced to a lesser degree than the reduced level of expenditure. This course could only be the right one if his costs of labour, feedingstuffs, etc., were in excess of requirements, or if the intensity of the system was too high in relation to the potential of the land and stock or the capabilities of the farmer himself, with the result that production was being achieved under conditions of diminishing returns. Or he may consider *expanding production* by adjustments or additions ; for example, when labour was not being fully employed he might increase his dairy herd or introduce a new enterprise such as pigs or poultry. Or again it may be a question of *increasing yields* per acre or per livestock unit.

The point I would make is that decisions such as these cannot be taken with confidence without a clear understanding of their financial implications. It is in these circumstances that the use of economic and financial data, the ability to analyse the farm business and to apply standards given in the handbook and elsewhere, are not only invaluable but indispensable.

There is no single or simple yardstick that will enable the farmer to know if he has the best combination of enterprises or if he is making the best possible use of his resources. It will, in the first instance, be necessary to form a general impression and appraisal of the farm and his farming system. Thus it is useful, when going round the farm, to have some idea of the gross production and probable costs involved. Such information may, of course, be obtained from the farm accounts, but as the latter may not be immediately available, it might be necessary to resort to estimates. The level of gross production obtained depends partly on the system of farming and partly on the yields. By assuming normal yields, the potential gross production of the system in practice on a given farm can be measured and appraised by comparing it with the gross production standards of local farming systems. This figure also, when compared with the actual level of gross production obtained on the farm (arrived at from an analysis of the farm accounts), will then give an overall measure of the individual farm crop and livestock yields. The unit gross production standards can also be used for budgeting the effects on gross production of adjustments in the farming system or the production programme.

Need for Local Knowledge

The handbook contains considerable guidance on analytical techniques and standards of economic and technical performance which provide the means for a fairly complete appraisal of any farming system. This information, however, may be justly criticized in that it is too general in nature for local use. The addition of a local supplement, combined with the local knowledge of the advisory officer, will go a long way towards overcoming this weakness. Farm management inquiries will not always require a complete analysis of the farming system. The advisory officer will frequently be confronted with requests for advice on minor management problems, such as the economic implications of substituting one cash crop for another. Or the farmer may wish to discuss the pros and cons of buying a new machine, such as a combine harvester. Decisions such as these may have little if any influence on fixed costs and can be dealt with by partial budgeting.

The *Farm Management Handbook* contains a fund of valuable information but it is only a beginning. There are still gaps to be filled which will become more and more apparent as the farm management approach is developed in the advisory service. There are, no doubt, omissions in the economic and financial data included, and the physical

data is not as complete as one would wish. Improvements and refinements in the content and quality of the handbook are, however, bound to result from the closer collaboration that now exists between the agricultural economist and the technical advisory officer. Nevertheless the book is a challenge to the N.A.A.S. and, in particular, to the D.A.O. on whom, in the first place, rests the responsibility for giving farm management advice. It is an attempt to meet more fully the demand for advice on the business side of farming, which will become increasingly heavier under keener competitive conditions and a freer national economy.

I am indebted to C.A.O.'s and Liaison Officers for opportunities to accompany them on actual visits to farms where management advice had been sought. There are more ways than one of developing and applying the technique of economic analysis to management problems. In some provinces more emphasis may be placed on farm budgeting, in others on a combination of the empirical and the analytical approach. In the first year or two the method of approach is not particularly important, provided the advisory officer realizes that farm management is no longer simply a technique based on subjective valuation and personal opinion.

The heaviest burden in connection with the introduction of the handbook will fall on the Farm Management Liaison Officers. Apart from the immediate need of instructing all general agricultural officers in the use of this manual, the Farm Management Liaison Officer has the responsibility of organizing courses for N.A.A.S. officers in the economic principles and analytical methods which form the basis of farm management as a science. The liaison officer has the further responsibility of establishing and maintaining the closest possible contact between the Provincial Economics Service and the N.A.A.S. It is only through such contact that we can hope to keep up to date with the work of the agricultural economists and their staffs, which is our main source of information on farm management issues. These are no simple or easy tasks to perform and every assistance should be given them to ease what is, after all, a heavy burden for one officer to shoulder in each province.

Farm management is concerned not only with the basic principles of crop and livestock production, but with the business side of farming as well. The overriding considerations in the mind of the adviser submitting plans to farmers should, therefore, be profitability, practicability and productivity.

ABSTRACTS

ANIMAL BREEDING

A Comparison of Various Selection Plans for Sheep Improvement (Summary). A. L. Rae. *Proc. N. Z. Soc. Anim. Prod.*, 1952, **12,** 58.

Reasonably accurate knowledge of the heritabilities, reproductive rates and selection differentials which affect economic characters in sheep flocks makes it possible to compare selection plans in terms of the annual rate of genetic gain expected. Such gains were estimated in New Zealand for a hypothetical flock of 1,000 ewes with known lambing percentage and replacement rate. Heritabilities were assumed to be 10 per cent and 40 per cent for two given characters.

At both levels, normal flock practice (i.e., individual selection of six two-tooth rams from the 500 available) was found to be least satisfactory. Selection of twenty rams per year and using them for one year only reduced the generation interval from three and three-quarters to two years, and increased the rate of gain by about 15 per cent. A flock which was divided into 30 per cent breeding nucleus and 70 per cent testing section—the nucleus using only progeny-tested rams and providing further rams for selection—could gain 10-15 per cent more than a flock using individually selected rams where heritability was low, but was no better at the higher level. A combination of individual and family selection on the sire proved to be almost as efficient as progeny-testing because of the reduced generation interval ; it also was most effective at a low level of heritability for the character concerned.

Selecting Lambs under Farm Flock Conditions. H. A. Karam, A. B. Chapman and A. L. Pope. *J. Anim. Sci.*, 1953, **12,** 148-64.

Indices were developed to reflect the major economic and heritable differences within a flock of Shropshires. Relative economic values were assigned to body weight (1.0), staple length (0.0, being unimportant within the variation found), and face covering (—1.5, being an adverse characteristic), which were all available at weaning, and estimated grease fleece weight (4.0). The effect of these on other characters only apparent later was considered in developing the indices.

Body weight less twice the face covering score was the index of greatest practical use, staple length giving little extra accuracy in relation to the labour entailed. It was also found that wether and single lambs

were definitely heavier than ewe and twin lambs, but differences in staple length and face covering were not significant. Heredity was found to govern 34 per cent of the variation in body weight at 155 days, 49 per cent of that in staple length at 239 days, and 61 per cent of that in face covering at 247 days.

K.v.O.

Progeny Testing in Sheep. J. W. McLean. *Technical Publication No.* 8. Lincoln College, University of New Zealand, 1952.

The simplest of experiments often yield the most startling results—this one certainly does. This paper records the results of work on the progeny-testing of Southdown rams in New Zealand. In that country the Southdown is bred only for cross-breeding to produce early-maturing, high quality, fat lambs from commercial ewes. In this work four- and five-year-old Corriedales were used. Rams were mated individually in paddocks to 25-30 ewes of comparable weights ; thereafter, all the ewes were run together and treated alike. Lambs were identified by ear tags at birth, weighed then and every month until sold fat off their mothers. After slaughter, all carcasses were weighed, measured and graded. In three years' work, 29 rams were progeny-tested—the purpose being to compare rams from different flocks. Some rams were in the highest price range at the annual ram sales (costing 14 guineas), others were breeders' rams (valued at 50 to 150 guineas), while others were culls which were given away. The rams used thus represented the whole range of merit as assessed by sheep breeders. Their respective offspring were assembled together at weaning time and no differences could be seen in size, conformation, condition or type, nor did the meat graders find any differences in the carcasses. Recourse to measurements did reveal differences between the progeny of different rams in birth weight, growth rate, dressing percentage and carcass conformation. Unfortunately, these differences were apparently unrelated to the cost of the rams or the flock from which they originated. As far as this sample of rams can be taken as representative, it shows that the selection of rams for cross-breeding as it operates at present is quite ineffective. Yet heritable differences between rams do exist for such important characters as growth rate and dressing percentage. If this type of experiment catches on it would behove breeders of several breeds of crossing rams to have more regard for the merit of cross-bred lambs and less for the pure-breds.

J.W.B.K.

Fleece Development

A. E. Henderson's study of the fleece development and wool growth of the Romney lamb [1] is both detailed and painstaking ; techniques are checked and their reliability discussed, and, from this point of view, the paper holds considerable interest. Other studies are quoted in the introduction showing that of the total variance in fleece weight of Romney

sheep, 10-15 per cent are due to additive genetic effects, 50 per cent to random environmental fluctuations, and 35-40 per cent are not accounted for. One of the primary questions posed by the author is whether permanent effects of early environment account for this last mentioned component of the total variance. This question is not answered convincingly ; the use of twins, or of different sire groups with larger numbers, would have permitted a wider interpretation of the data than was, in fact, possible.

Twenty lambs (singles and twins reared as singles) out of different ewes but all by the same sire, were divided initially into two groups—one on a high, the other on a low plane of nutrition. From twenty weeks old (weaning) to one year, one half of each group continued on the opposite management level, thus creating four treatments each with five lambs. Among the conclusions drawn were that immediate environment was the most important to wool production, and that early environment affected mainly the skin area available for wool growth. Fibre numbers were not limited by skin extent, and treatments could not be shown to have a permanent effect on them.

Fraser puts forward a hypothesis relating wool growth to the available level of fibre substrate. Fibre development is conceived as resulting from competition between follicles which have different efficiences for their job. The concept was derived from the relationship noted between fibre shape and the type of follicle from which it is derived [2]. The different fibre shapes were related to differing rates of growth and ages at initiation.

In his second paper [3] the efficiency idea is related to the growth of the N-type fleece in Romneys. The N-gene causes increased growth of primary fibres and a corresponding decrease in the growth of secondaries. This is thought to be due to greater efficiency in competition for fibre substrate of primary follicles at the expense of those forming fibres later. Fraser's third paper [4] discusses probable factors entering genetic determination of fleece structure : fibre substrate, follicle efficiency, time of fibre initiation, and fibre density. Interactions between these factors are postulated. From these and other considerations the author claims to chart the course of evolution of fleece types, but he is first to admit that much quantitative verification will be required before the hypotheses of these studies become basic theory.

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White Heifer Disease in a Herd of Dairy Shorthorns. J. M. Rendel. *J. Genet.*, 1952, **51**, 89-94.

The form of sterility known as white heifer disease appears to be due to failure of the Müllerian ducts to develop properly. It is commonest in white heifers of the Shorthorn breed, but has also been found in roans and reds and amongst coloured animals of other breeds. Rendel analysed the occurrence of the condition in one large herd, where the material consisted mainly of female offspring of seven bulls, as follows :

Bulls	Female Offspring					
	Red		Roan		White	
	Normal	*Affected*	*Normal*	*Affected*	*Normal*	*Affected*
2 Red ...	25	1	21	1	0	0
4 Roan ...	69	0	69	2	14	8
1 White ...	0	0	25	1	0	1

It can be seen that the condition is not limited to white heifers but increases in frequency from red to roan to white. Herd book data is used to show that the proportion of affected white heifers in the population as a whole is smaller than in the herd studied. Pedigree analysis did not reveal any possible reason for the apparently high frequency of the condition in the herd. It was found, however, that white daughters of white dams in this herd had a greater chance of being sterile than white daughters of roan dams. There is some indication that environmental conditions may modify or increase the appearance of the disease. The white gene is maintained in the breed by a preference for roans since there is some selection against white animals. The preference is hard to understand since red cows on first lactation gave significantly more milk than roans or whites. These disadvantages associated with the white gene make it surprising that it has survived so long in the breed.

G. W.

SOILS

During recent years considerable attention has been paid to changes that take place in glasshouse soils as a result of steam sterilization. Recent abstracts in this Journal of publications dealing with glasshouse soils (No. 19, 306-7) have reviewed work on the physical aspects of steam sterilization, and the microbiology of steamed soils, and referred to the latest report then published of the work in progress at the Experimental Research Station at Cheshunt on ammonification and nitrification in soil following steam sterilization.

Apart from the control of plant diseases, which is the chief function of soil sterilization, it is important to discover the extent to which the availability of plant nutrients may be affected if balanced growth is to be achieved. The following two publications throw some light on this aspect of the subject.

Damping av jord til tomat (Steaming of Soil for Tomatoes). Jens Roll-Hansen. *Rep. State Exp. Sta.*, Kvithamar, St. Jordal, Norway, No. 10, May 1952.

In a number of experiments conducted in Norway on tomatoes growing in steamed soils under glass, Jens Roll-Hansen observed there was a 75 per cent increase in yield, but a slight delay in ripening reduced the economic gain to 70 per cent. Discussing the changes in the soil brought about by steam sterilization, he reports that, although the immediate effect was to increase the ammonia content, the nitrate content fell. Contrary to frequent statements in literature on the subject, the content of readily absorbable nitrogen (computed as the total of nitrogen in the form of ammonia and nitrate), according to his analyses, often showed a decrease. In support of this, he points out that there was adequate nitrate in the unsteamed soil, and he does not consider that the weaker growth of plants on the unsteamed soil was due to a lack of nitrate.

Plant analyses showed that ordinarily the dry matter content of plants grown in steamed soil was lower. The nitrogen content in the dry matter was often proportionately higher, the phosphorus content was considerably higher, as were also the contents of manganese and copper, the potassium was a little higher and the calcium lower. There was increased absorption of both iron and zinc after steaming. The author indicates that the effect on the manganese content is very considerable; in the plant material from 500 to 1,000 per cent more manganese was found than from unsteamed soil. He shows that spring steaming gives a higher manganese uptake than autumn steaming, and that this increase is observed in all parts of the plant and in the fruit. Frequency of steaming also increases the manganese, especially when steaming is performed immediately before the tomato plants are set out in the steamed soils. This, however, does not also hold for zinc. It is thought that these increases in manganese are brought about by the reduction processes going on in the soil as a result of steaming.

Roll-Hansen concludes that the more favourable growth of tomato plants on steamed soil was in part due to a more favourable balance of nutrient substances, and, possibly, to lowered competition amongst organisms for these nutrients.

Some Observations on the Chemical Changes Effected by the Steam Sterilization of Glasshouse Soils. T. W. Walker and R. Thompson. *J. hort.Sci.*, 1949, **25**, 19-35.

These two workers have studied soil before steaming and at intervals thereafter from three commercial glasshouses in this country. They

also found a rise in ammonia nitrogen and a fall in nitrate after steaming, but no consistent effect on the sum total of the two forms of nitrogen. They observed that steaming greatly increased the water-soluble oxidizable organic matter, and produced a definite increase in water-soluble manganese, the concentration slowly decreasing on storing. Depending on soil conditions, the authors suggest that the retardation in growth of plants after steaming may be due to one or all of the three factors : ammonia, toxic organic compounds or available manganese. The first two factors generally go hand in hand, and are greatest in rich soils of high *p*H, whereas in soils of low *p*H, manganese may be the most important factor.

In order to overcome or reduce such adverse effects on plant growth it is suggested that the soil should be either limed or manured some time before steaming, and should be as dry as is necessary for the efficient destruction of pathogenic organisms. With such conditions, it should be possible to exercise a considerable measure of control on the production of nitrogen and achieved balanced plant growth.

Abstractor's Note

A number of cases of failure in horticultural pot plants have been investigated recently, and have been found to be due to manganese toxicity as a result of steam sterilization. The soil *p*H was not necessarily low. In a general way the symptoms resembled those of iron deficiency, but varied with plant, stage of growth, and degree of toxicity.

M.N.N.
C.W.R.S.
W.M.D.

Sawdust and Soil Improvement

Experimental work on the use of wood wastes in soil improvement was reviewed in this Journal (No. 19, p. 304 and No. 20, p. 341). Stuart Dunn has continued his investigations with L. J. Wolf and W. A. Macdonald (*Plant & Soil*, 1953, **4**, 223 and 225) by studying the methods of composting sawdust and measuring the effect of composts on plants in pot cultures.

Wooden bins of 16 cubic feet capacity, pierced at the sides for aeration, were filled with four different mixtures : (1) two-thirds sawdust and one-third cow manure from bedding on sawdust ; (2) two-thirds sawdust, one-third cow manure litter as above, and 5 lb. urea ; (3) two-thirds sawdust and one-third loam ; (4) rotted wood and 5 lb. urea. These mixtures were allowed to decompose with the addition only of the natural winter rainfall for New Hampshire, U.S.A.

After a year, analyses showed that the composition of Mixtures 1 and 2 was similar, and that there were slight differences between 3 and 4, which were both lower in nutrients than the first two. Pot cultures with runner beans and potatoes showed that the period was too short for

proper decomposition, due, probably, to insufficient moisture. After a further two years of decomposition (three years in all) it was found that the N,P,K and *p*H levels were all higher than after the first year. Pot cultures at this stage with a succession of oats, sunflowers, tomatoes and potatoes, showed that no compost equalled soil as a growth medium, although Mixture 2 gave a good yield of potatoes. At the end of the pot culture work the *p*H value of the mixtures was between 4.4 and 4.9.

Poultry manure—especially under the litter system of housing—has proved to be a useful material for composting with sawdust, and some trial outdoor compost heaps were made with it and with fresh, chopped legume-grass mixtures. The heaps contained : (1) one-quarter poultry manure and three-quarters sawdust ; (2) one-tenth poultry manure and nine-tenths sawdust ; (3) one-half chopped herbage and one-half sawdust ; (4) sawdust only—largely coniferous ; (5) one-third poultry manure, one-third chopped herbage and one-third sawdust. Water was given liberally to ensure thorough mixing. Heating was generally rapid, especially in the herbage-sawdust mixture, which reached 69.5° C., although the triple mixture of poultry manure, sawdust and herbage took a fortnight to rise to 54° C. After five months, all but one of the composts had a *p*H value of 6.6 : the exception was Heap 4—the sawdust only—which had 4.8.

Culture experiments with radishes, sunflowers and soya beans showed that the most generally useful mixtures were one-quarter poultry manure and three-quarters sawdust, and one-half chopped herbage and one-half sawdust, and that decomposition had not gone far enough in the time. Further pot culture tests after a further seven months (a total of one year for decomposition) were made with successive crops of maize, soya beans and potatoes. The triple mixture was the best from the start but it was found that after two crops this compost, and that produced by one-quarter poultry manure to three-quarters sawdust, were completely decomposed, so that the individual ingredients could not be recognized. Plentiful water and the nitrogen in the poultry manure had much to do with the reasonably quick decomposition of the sawdust.

Attempts were made to hasten the processes of decomposition by using steam and 1 per cent sulphuric acid, separately and in succession, but they were not successful, and in fact the resulting material was damaging to plants. Composting with fish waste for three months gave products with a *p*H of 8.22-8.75, as compared with the 4.52 of the original sawdust. The high *p*H was caused largely by the high ammonia content. Plant growth was again poor. On the other hand, encouraging results were obtained using urea and sodium nitrate in a 3 : 1 soil-sawdust mixture. Nitrate was better than urea for breaking down sawdust.

The general conclusions to be drawn are that sawdust is a useful source of organic matter provided that it is properly decomposed by some material supplying nitrogen before being incorporated with the soil. Of the materials which are suitable and easily available, poultry manure is probably the best.

J.B.E.P.
W.M.D.

CROP HUSBANDRY

Tetraploid Rye

Shortly before the Second World War it became widely known that colchicine could be used to increase the chromosome number of plants. Preliminary investigations indicated that those plants whose chromosomes had been doubled (tetraploids) were often more vigorous and more productive than normal (diploid) plants. It seemed an obvious step towards increased agricultural production to obtain tetraploid varieties of farm crop plants.

Expectations have not been completely realized. A report from Sweden (*Statens Forsøgsvirksomhed i Plantekultur*, 1953, No. 492) gives some results of trials with tetraploid rye during the three seasons 1950-52. Two varieties, Steel and Petkus, were used, each being available in the normal and in the tetraploid forms. In all three seasons the tetraploid rye gave a considerably smaller yield of grain than ordinary rye, despite the fact that individual tetraploid grains are much larger than normal grains ; the yield of straw was also lower, though the length was the same. The report states that tetraploid rye has not, so far, fulfilled its expectations with regard to a greater grain yielding ability, and the lower yield is not balanced by a greater stiffness of straw. The danger of pollination from ordinary rye and the consequent poor setting of grains is also a drawback which must be taken into consideration in the growing of tetraploid rye.

Wild Oats

In Sweden there has been an increase in the population of wild oats due to a decline in the area of bare fallow, increased mechanization and large purchases by farmers of seeds and feedingstuffs from merchants and other farmers. The spread is regarded as very serious and, in March 1952, regulations were made to try to halt it. The regulations state that any grain or tail corn which contains more than 15 seeds of *Avena fatua* per kg. (2.2 lb.) must be cracked or ground before it can be offered for sale. Seed grain must not contain more than 15 seeds per kilo, but " National Seal " grain must not contain more than 5 seeds, and " Elite " seed not more than one seed of wild oat per kilo.

A note on the selective control of wild oats in cereal crops by maleic hydrazide has been published by George Knowles (*Can. J. agric. Sci.*, 1953, **93,** 402). He states that the margin of difference between the time at which some cereal crops reach the heading stage of growth and the time at which wild oats (*A. fatua*) reach that stage may allow selective control by the application of maleic hydrazide. One pound per acre of maleic hydrazide, sprayed with a wetting agent on cereal crops and wild oats when the barley and wheat had been in head for six days and the cultivated and wild oats were still only in the " shot blade " stage, caused almost complete sterility of the wild and

cultivated oats, but did not materially affect the yields of barley and wheat. The germination of the wheat seed was very considerably reduced by the treatment, but the germination of the barley was little affected. Further trials are contemplated.

Potatoes

Trials to investigate the influence of time of planting, and also of spacing, of potato seed were started at Sprowston in 1948, and a brief report is now available (*44th Ann. Rep. Norfolk Agricultural Station*, January 1953). The effect of time of planting on yield varied with the season and the variety. In most seasons Majestic gave its highest yield of ware tubers when planted in late March ; planting in mid-April led to a loss of 12 cwt. of ware per acre, and planting in early May to a further loss of 24 cwt. per acre. Arran Banner, however, gave the same yield of ware when planted in March or April, and the loss due to late planting was only 14 cwt. per acre. It was not possible to correlate the behaviour of the varieties with climatic factors such as rainfall.

In the spacing trials, evenly graded seed was planted (in 28-inch rows) at 12-, 16- and 20-inch distances. In each of the three seasons the total yield of tubers was not affected by differences in spacing. But, " whereas 29 per cent of the total yield on the 12-inch plots was of seed size, from the 16- and 20-inch treatments the proportions were 23 per cent and 20 per cent respectively. Thus the increase in the distance between the setts from 12 to 20 inches increased the yield of ware by nearly 1 ton per acre and saved over 33 per cent on seed. But since sprouted stock was used in all these trials the proportion of misses was small and this is important when contemplating the adoption of wider spaces."

The results of elaborate trials at Edinburgh in the two years 1946 and 1947 are reported by Muktar Singh, under the title " The Influence of Cultural and Manurial Factors on Plant Development and Yield of the Potato" (*Emp. J. exp. Agric.*, 1952, **20,** 301-15). Among the conclusions drawn may be mentioned : the tuber number decreased with decrease in seed size ; close spacing acted like large seed on growth and yields, but a unit change in spacing produced more effect than a unit change in seed size ; large seed should not be close planted ; the superiority of early planting was enhanced by close spacing and nitrogen application ; nitrogen increased the size of the tuber, the proportion of ware, and the yield ; nitrogen acted best with early planting, small seed and medium (12-inch) spacing.

A. R. Wilson and J. A. Dawson (*J. Sci. Fd Agric.*, 1953, **4,** 305-10) have recently reported upon residues of tetrachloronitrobenzene on ware potatoes. This material, TCNB, forms the basis of a proprietary powder " Fusarex," which has been used successfully to depress sprouting of stored ware potatoes. They point out that although TCNB is known to be of a low order of toxicity to animals, it is important to know the amount which is likely to reach the consumer. During the 1949-50 and 1950-51

storage seasons, ware potatoes were treated with 10 lb. per ton of 3 per cent TCNB dust. Examination after normal commercial grading and transport following 4-5 months' storage suggested that concentrations of TCNB on tubers might be about 2 parts per million. After 6 months' storage, a reduction to 1 p.p.m. is probable. Washing reduces residues still further and no TCNB at all was found in the flesh of peeled tubers. Although it is not specifically stated in the report, the conclusion must be that TCNB applied in a proper and normal manner to stored ware potatoes is unlikely to harm human beings.

G.E.F.
D.H.R.

MACHINERY

Economic Facts about Tractors. *F.R. No.* 116, University of Nottingham School of Agriculture, Dept. of Agricultural Economics, 1952.

This report gives details of the cost of operating thirty-eight tractors on twenty-two farms in the East Midland Province during the year February 1951 to January 1952. Three of the tractors ran on petrol, one on Diesel oil and the rest on vaporizing oil, and all were light-medium or medium powered within the range of 24 to 40 b.h.p. There were two tracklayers. The average number of hours worked was 925, and the average annual cost was £144 9s., of which £79 18s. was for fuel, £19 8s. for repairs and £42 2s. depreciation. The average cost per hour was therefore 3s. 1½d. (excluding the driver's wages). Cost of fuel, oil and repairs were from records of consumption, calculated on the basis of 3s. 7d. a gallon for petrol, 1s. 4d. for vaporizing oil and 1s. 2d. for Diesel oil. Depreciation was calculated at 28⅛ per cent of the written-down value at the beginning of the year.

An appendix gives the figures for individual farms and shows the wide range in hourly cost of operating individual tractors (1s. 7d. to 5s. 10d.). This difference is accounted for, to some extent, by the method of charging depreciation, and it is difficult to understand why the more realistic " weight-for-work " basis should not be adopted for assessing tractor operating costs.

Elsewhere in the report, information is given on the type of work done, seasonal usage, and (over a bigger sample) the farmers' expectation of the total life of their tractors, while a final section deals with the replacement of horses by tractors during the period 1939-52.

Resistance to Airflow of Various Types of Floor Blocks for Ventilated Grain Silo and Other Driers. *N.I.A.E. Technical Memorandum No.* 95.

The floor is a vital part of any ventilated grain silo in which the grain is ventilated from the bottom and has to be dried as well as stored, for the grain often needs to be ventilated at fairly high air velocities over long periods. In these circumstances it is important that the floor itself should have a low resistance to air flow. This report deals with tests using foamed slag blocks, porous blocks made of " no fines " concrete to a special specification, blocks made of an aggregate known as " Leca," perforated concrete blocks with tapered apertures 2 inches by $\frac{1}{16}$ inch at the top and having a total free area of 3.5 per cent, and malt kiln tiles with $\frac{3}{32}$-inch diameter holes giving 4.6 per cent free area. The blocks were tested in a laboratory rig having a floor area of 1 square yard, and were covered with 6 inches of grain. (Separate tests showed that the covering of the blocks by grain produced a marked increase of resistance compared with testing the blocks alone.) The results are presented in the form of graphs showing air flow against resistance. At an air flow of 15 c.f.m. per square foot of floor area, the resistances of some of the floors tested (all covered with 6 inches of grain and not pointed) were :

	Resistance
	(*in. w.g.*)
Malt kiln tiles	0.03
Slotted concrete blocks	0.10
2-inch commercial " Leca " blocks (fine)	0.25
2-inch commercial foamed slag blocks	0.63

The results show that at air speeds of 15 c.f.m. per square foot or above the use of floors which have a lower resistance than commercial foamed slag blocks may be desirable.

Experimental Outdoor Grain Storage Silos. Interim Report. *N.I.A.E. Technical Memorandum No.* 98.

An account is given of work using cylindrical outdoor silos of 20-ton capacity, constructed of aluminium alloy, concrete slabs with galvanized steel roof, resin bonded plywood, and galvanized steel sheet. The silos were filled in October 1952 with wheat that had been dried to about 15 per cent moisture content. Observations of the weather were made throughout winter and early spring, and also of grain moisture content, temperature, germination, and baking quality. The silos were emptied in April 1953.

The grain kept satisfactorily in all the silos, but a very small proportion of damp and mouldy grain was found on some of the floors when the silos were emptied. It was not certain whether this was caused by the

floors being still damp when the silos were filled, or was due to water entering between the silo walls and the bases. When the metal silos were emptied, some grain was left in the horizontal internal crevices between adjacent sheets. There was some slight penetration of water between the staves of the concrete silo walls, but the amount of grain damaged was very small. It is recommended that the minor troubles encountered should be further studied, and the work is to be continued during the 1953-54 season.

Methods of Applying Fertilizers for Herbage Crops. G. W. Cooke and F. V. Widdowson. *J. agric. Sci.*, 1953, **43,** 358.

A review of the literature concerning American experiments and analogy with work on arable crops previously carried out and written up by the same authors, showed the need for experiments to determine the relative efficiency of fertilizers applied in various ways to such crops as lucerne and sainfoin. Experiments on several crops were laid down in 1950 and 1951 using a special drill originally built by the National Institute of Agricultural Engineering for the earlier experiments on row crops. Crops experimented on included established crops and new lucerne leys. Established crops included sainfoin, winter oats undersown with sainfoin, permanent grass and lucerne-cocksfoot ley. The two methods of application tested were fertilizer broadcast and fertilizer placed in bands 3 inches below the soil surface and (generally) 10 inches apart. Each method of application was tested at two rates of dressing : $3\frac{1}{4}$ cwt. and $6\frac{1}{2}$ cwt. per acre of a granular fertilizer containing 16 per cent P_2O_5 and 13 per cent K_2O. One of two no-manure plots was cut with the fertilizer placement drill in order to assess mechanical damage, if any. Results on the established crops showed that in no case was there any advantage in the band placement method compared with broadcasting. In fact, broadcast yields were generally significantly higher. There was only one case (permanent grass at Rothamsted) where placing fertilizer gave a significant increase over the no-fertilizer plots. The cutting of grooves 10 inches apart in permanent grass and lucerne-cocksfoot ley produced a slight decrease in yield : this was, however, insignificant. The conclusion was reached that there is no case for subsurface placement of fertilizer in established swards.

In the experiments on lucerne laid down in 1950, broadcasting phosphate-potash fertilizer on the seedbed was compared with placing it 2 inches to one side of the seed and 3 inches deep. On one set of plots, half the fertilizer was applied at seeding and half the next spring. There were no improvements in early growth or establishment from the placement method. In a 1952 experiment a basic comparison was made between broadcasting on the seedbed either superphosphate, muriate of potash, or a mixture of the two, and broadcasting it on the stubble and ploughing in at the beginning of seedbed preparation. In addition, half the plots had a " starter dose " of 2 cwt. per acre granular superphosphate, placed 2 inches directly below the seed. The effect of the

" starter dose " on early growth was outstanding. It produced a vigorous early growth which was significantly superior to that on plots where fertilizer was broadcast. Ploughing in the broadcast dressing at the beginning of seedbed preparation tended to give a higher yield at the first cut. The conclusion was reached, however, that the most satisfactory method is to broadcast the basic fertilizer dressing on the seedbed, and apply a small starter dressing of superphosphate immediately below the seed, using a suitably modified combine drill.

Reference is made to an American article, " Band Seeding Method for Meadow Crops " by J. L. Haynes and L. E. Thatcher (*Ohio Farm and Home Research*, 1950, **35**, No. 262), in which a brief description is given of the use of slightly modified, commercially available equipment to effect such placement. This consists of the use of a " grass box " which is attached to and driven by the combine drill, and delivers the seed through rubber seed tubes just behind the drill coulters. Unfortunately, grass boxes of the type referred to are not at present available in Britain, but it would not be difficult to develop suitable attachments for lucerne sowing.

C.C.

FRUIT

Effect of Night Temperature on Growth of the Fruit of the Sour Cherry. Loren D. Tukey. *Bot. Gaz.*, 1952, **114**, 155-65.

Sour cherry (*Prunus cerasus* L.) fruits, like apricots, peaches, plums, and sweet cherries, are known to develop in three distinct stages :

Stage I extends from full bloom until the hardening of the stony pericarp. It is a period of rapid development of the fleshy pericarp, at first by cell division and, later, by cell enlargement.

Stage II is a period of retarded development of the fleshy pericarp ending at the beginning of its second period of rapid growth. During this stage the embryo grows rapidly from microscopic size to its maximum length of about 6 mm., and the stony pericarp becomes thickened and greatly hardened.

Stage III, the second period of rapid development of the fleshy pericarp, is commonly known as the " final swell ". Growth is mainly by cell enlargement, the largest cells being 250 times their diameter at full bloom. During this period only slight changes take place in the stony pericarp or in the embryo.

It has been shown with apricots that night temperatures markedly affect fruit growth at each of these three stages, and similar experiments

were carried out on sour cherries in 1948 and 1949 in Ohio. Branches of Montmorency cherry were enclosed in two separate chambers in which the desired temperatures were maintained each night from 7.0 p.m. to 8.0 a.m. The results showed that the night temperature which produced the most rapid development was lower in Stage III than in Stages I and II; the lowest average temperature experienced in Stage III (62.0° F.), and the highest in Stages I and II (79.5° F. and 87.8° F., respectively), gave the most rapid growth. The optimum day temperatures were not recorded, but the best night temperatures in Stages I and II were higher, and in Stage III lower, than the prevailing day temperatures. These results substantiate observations made by various workers that warm temperatures late in the season lengthen the number of days to maturity.

The stages of development of the cherry fruit, apart from their duration and the relative growth of the different parts of the fruit, were not affected by the temperature treatment. The total number of days needed to reach maturity (about 54) was approximately the same under the different night conditions, although, theoretically, it would be possible to reduce this period to 39 days or less by providing night temperatures that were high for Stages I and II and low for Stage III. The size of fruit at maturity was affected only by the highest temperature conditions (91.2° F.), when the fruits were the smallest. These fruits had poor colour and low total soluble solids, and the leaves on the treated branches were yellowish-green in colour.

It appears undesirable to grow sour cherries in warm climates, and in the U.S.A. the chief areas of production are located in the north-east, where cool night temperatures prevail during Stage III; this factor is, however, not the only one involved.

H.B.S.M.

NUTRITION OF HORTICULTURAL CROPS

Adaxial Crack Stem of Celery. J. T. Middleton, B. J. Hall, R. T. Wedding and J. B. Kendrick, Jr. *Phytopathology*, 1952, **42**, 603-6.

A nutritional disease of Utah-type celery affecting the surface of the petioles has been reported in the coastal region of southern California. Affected tissues appear water-soaked and eventually turn into necrotic patches; the final syndrome is characterized by the advent of a corky surface, transversed with cracks. Strangely enough, there is no secondary infection involving any plant pathogen. The appearance of cracked stems occurs most frequently in plantings which have received large amounts of either organic or inorganic nitrogen.

Borax sprays (0.1 per cent), applied at the rate of 62 gallons per acre, prevented the recurrence of symptoms after 45 days.

Boron Requirement of Greenhouse Roses. S. Asen and O. W. Davidson. *Proc. Amer. Soc. hort. Sci.*, 1952, **60,** 439-48.

Greenhouse roses are grown in America under cultural conditions conducive to boron deficiency. Contributory causes, such as excessive leaching of greenhouse soils, are cited to explain the depletion of boron. The more general use of inorganic as opposed to organic manures is also mentioned.

For experimental purposes, roses were grown in boron-deficient sand cultures. It was found that flower production as well as quality was affected by the concentration of this mineral in the sand cultures ; its onset is characterized by die-back of the stem tip and flowering shoots. The optimum amount of boron in the rooting substrate (0.25 p.p.m.) gave 20-40 p.p.m. in the leaves. The amount of boron in the foliage, however, was affected by other nutrients : increasing sodium or calcium concentrations lowered the boron content of the leaves, while high potassium or low sodium concentrations increased the levels.

A systematic survey was made of the boron status of greenhouse roses in the United States. The supply in 16 per cent of the samples was sub-optimal, whilst 12 per cent showed well-defined deficiency levels. The type of watering practised by growers influenced the amount of the mineral in the leaves ; plants watered by the constant water-level method contained 0.10 per cent more boron than those in hand-watered beds. As roses, apparently, are one of the most intensively watered greenhouse crops, and as boron is readily leached from the soil, it is suggested that the addition of boron to rose soils is warranted.

Relation of Calcium Nutrition to the Incidence of Blossom-End Rot in Tomatoes. H. J. Evans and R. V. Troxler. *Proc. Amer. Soc. hort. Sci.*, 1953, **61,** 346-52.

The physiological disease of tomatoes known as blossom-end rot is characterized by a water-soaked area at the base of the fruit, which eventually turns brown or black and becomes infected with micro-organisms.

Experiments are described using high Ca fertilizer applications, calcium chloride sprays and calcium gluconate injections. In field experiments, the application of 1,000 lb. CaO in the forms of phosphate gypsum and calcium nitrate, and two sprays of calcium chloride solution, significantly reduced blossom-end rot. In the greenhouse, plants sprayed weekly with calcium chloride solution (1 per cent) produced less blossom-end rot fruit than controls. Injection of fruit with 2 per cent calcium gluconate solution reduced the incidence of the disease from 29 to 2 per cent in the field.

These experiments indicate that blossom-end rot is possibly caused by an insufficient supply of calcium for the synthesis of rigid cell walls in the fruit. W.P.

DAIRY HUSBANDRY

Milking Method

New information on udder function and the effect of milking method on milk production and quality has been published recently from a number of research centres. Johansson, Korkman and Nelson (*Acta agric. Scand.*, 1952, **2,** 43-81) have provided more precise data on the differences in the fat content of milk which are found in samples taken periodically during any individual milking. Johansson (*Acta agric. Scand.*, 1952, **2,** 82-102) has also collected more data on the quantity and composition of the residual milk which is always left in the udder after hand-stripping following normal milking by machine. These workers found in machine-drawn milk a mean rise in fat content from about 2 per cent in the milk produced first, to about 10 per cent in the last drawn milk. This rise was usually slow in the first phases of milking but much more rapid near the end. Where a single oxytocin injection was given five minutes after the conclusion of a normal milking, a further milking resulted in the production of 12.8 per cent of the total milk yield and 32.3 per cent of the total fat yield. This, however, apparently still did not represent complete evacuation of the udder, and in experiments in which three successive injections of oxytocin were given at 15-minute intervals after normal milking, and another milking carried out after each injection, further milk and butter fat was obtained in greater quantities than would be accounted for by normal rate of secretion into the udder. The results of this work emphasize the strong retentive capacity of the udder for the final residuum of milk and, particularly, of butter fat. At the same time the results indicate that, at the point of concluding a normal milking, the leaving of small quantities of milk which might be obtained without departure from normal practice can have a substantial influence on the fat content of the total milk at the particular milking.

In his paper Johansson suggests that the rise in fat content of milk as the milking proceeds may be due to the retarding of the larger fat globules during their passage from the alveoli to the gland sinus. Whittleston (*J. Dairy Res.*, 1953, **20**, 146-53) suggests that the effect may be due to clustering of fat globules and a partial filtering out of the clusters as the milk flows through the ductlets.

While the immediate effect of incomplete milking on yield and fat content are well known, less has been published concerning the cumulative effect of incomplete milking over long periods, and the subsequent effect when normal milking is reintroduced. Bailey, Clough, Dodd, Foot and Rowlands (*Thirteenth International Dairy Congress*, 1953, **2,** 76-82) studied this aspect by comparing the yield and fat content of milk from the two halves of the udder in seven cows over a period during which, for 51 days, one-half of the udder was carefully hand-stripped and the other half was left without stripping. During the 51 days the absence of stripping (by hand or by machine) resulted in a deficit in yield which increased up to a maximum of about 14 per cent 6-7 weeks after

stripping ceased. The deficit persisted two weeks after stripping was reintroduced, but at a reduced level of about 6 per cent below the control half-udder. Fat percentage was substantially reduced during the first 2 or 3 days after stripping ended, and remained at a slightly (but usually significantly) lower level during the 51 days of non-stripping. When hand-stripping was resumed, the fat percentage returned to values similar to those obtained before hand-stripping was stopped.

Further data on the influence of vacuum level and duration of milking on udder health have been obtained by Mochrie, Hale, Eaton, Elliot, Plastridge and Beall (*J. Dairy Sci.*, 1953, **36,** 504-15). In a comparison of the effect of vacuum levels at 10, 13 and 17 inches of Hg over a period from the fifth to the forty-fourth week of lactation in 12 heifers, none of the direct or indirect methods of assessing udder health revealed any differences due to vacuum level. In comparing one half of the udder milked for the normal duration with the other half milked for twice the normal duration throughout the experimental period, no differences between halves were obtained so far as concerns freedom from organisms, teat erosions or udder fibrosis. In some of the indirect tests for mastitis, e.g., leucocyte counts and chloride values, significantly higher values were obtained for normal duration than for twice normal duration. This result is surprising in view of the common belief that the incidence of mastitis is liable to be increased by leaving the teat cups on the cow longer than necessary. In this study, first-calf heifers selected for freedom from mastitis were used, and it is unwise to assume that older cows with initial sub-clinical infections would give similar results.

Rate of Milking

Rate of milking has recently been the subject of further study. Whittlestone and Phillips (*J. Dairy Res.*, 1953, **20,** 319-26) have described an automatic apparatus for recording and plotting the flow curves for individual milkings. Dodd (*J. Dairy Res.*, 1953, **20,** 301-18) has studied data concerning the milking rate of 141 cows for 326 lactations, with particular reference to those factors which have a less obvious association with rate of milking.

Previous evidence that milking rate is closely associated with the size of teat orifice has also led to studies of the correlation between milking rate and the various measures of yield and milk quality. In a group of 86 first-calf heifers, Dodd and Foot (*J. Dairy Res.*, 1953, **20,** 138-45) have found a highly significant correlation between the peak rate of flow during a milking and the lactation yield. For each pound per minute increase in peak flow, the standard lactation yield increased by 419 lb. of milk, the maximum daily yield by 0.9 lb. and the lactation length by 8 days. Since there is some evidence that the milking rate is inherited, the commercial significance of milking rate or teat orifice size may not be limited to the saving in labour at milking. While a large teat orifice may be a desirable aim in breeding, it must also be borne in mind that evidence of greater incidence of mastitis has previously been shown to be associated with milking rate by Dodd and Neave (*J. Dairy Res.*, 1951, **18,** 240-45).

Rate of milking is also affected by the operation of the milking machine, and previous reports have described the association of vacuum level with rate of flow. Pulsation rate has often been thought to have little effect on rate of milking, except in so far as it may stimulate or retard ejection or " let-down ". A recent report by Clough, Dodd and Hughes (*J. Dairy Res.*, 1953, **20,** 375-80) describes experiments in which increased rate of flow is closely associated with an increase in pulsation rate from 20 to 80 cycles per minute, even when the effect on ejection is eliminated, and due, apparently, to changed mechanical conditions in the teat cup.

Thyroprotein and Thyroxine in Milk Production

A large number of papers reporting on the stimulating effect of thyroid-active materials on milk production have appeared during the last decade. There has, however, always been some doubt as to the long-term effect on yield and health of dairy cattle where these materials have been used over several lactations. Two recent papers have provided valuable information on this aspect. Thomas and Moore in America (*J. Dairy Sci.*, 1953, **36,** 657-72) have fed Holstein and Jersey heifers with iodinated casein, mostly at 1 or 1.5 grm. per cwt. body weight daily from the fiftieth day after calving until ninety days before the next calving, and have continued the same treatment for subsequent lactations up to the sixth in some cases. Aitken, Boyne and Crichton (*J. Dairy Res.*, 1953, **20,** 291-300) in Scotland have fed 20 grm. iodinated casein (or equivalent L-thyroxine) to Ayrshire and Red Poll heifers from the seventeenth to the twenty-ninth week after calving, and again the treatment has been repeated in subsequent lactations for all animals remaining in the experimental herd up to the fourth lactation. In these investigations comparable control cattle were kept without the thyroid-active material.

In both experiments a marked stimulation in yield was generally obtained immediately after thyroprotein feeding began. The enhanced yield compared with controls varied in extent and duration according to the level of nutrition and the amount of flesh on the experimental animals, but it always began to diminish a few weeks after the start of treatment and often disappeared before the thyroprotein was withdrawn. In some cases the yield of controls exceeded that of the treated animals in late lactation. The stimulating effect of the thyroprotein also appeared to be reduced in lactations after the first, and in both investigations the conclusion is reached that no overall increase in production was achieved by using these materials, although short-term effects can be substantial. Little adverse effect on health and reproduction was noted where thyroprotein was used, although in the American work a higher mortality rate in calves from the treated cows was reported. Loss in body weight during treatment was marked in both investigations.

A.S.F.

ENTOMOLOGY

How Far Do Insects Travel? C. B. WILLIAMS. *Rep. Rothamsted Exp. Sta.* 1951, 173-80.

The extent to which insects are capable of moving from one place to another is of great importance to all those concerned with the control of pests. This article answers many of the speculations which are often made as to whether a crop is likely or not to escape attack by a pest if moved such and such a distance from the field where trouble occurred in the previous year. Much interesting information is given, which is considered from the angle of definite migrations and from the aspect of the more passive form of movement known as " insect drift ". These questions are also linked with the length of life of insects. It is pointed out that an adult life of less than a week is probably unusual in flying insects, and that some live weeks, months or even years. The possibilities of movement within a life of even a week are great, and it is now known that, even in 24 hours, the distances covered could be measured in miles rather than in yards. The futility of moving a crop from one field to the next in order to " fox " the average insect pest looking for its food, is made clear.

Of particular interest are the figures given for the capture of moths in a light trap at Rothamsted over a period of four years. During that period 240 different species of moth were captured; some may have bred within a few yards of the trap, but others may have migrated from several hundred miles away. It is pointed out that had the trap been a plant newly introduced to the area, then in four years about one-third of all the kinds of British moths would have been near enough to that plant to decide if it were suitable for breeding purposes.

Much interesting information is given on the migration of insects and this is supplemented by an account of some of the results obtained in the trapping of insects in the upper air. For enormous population of insects drifting through the upper air is made apparent by the fact that, at a height of 2,000 feet, as many as 20 living aphids could be trapped in an hour on a summer's day in a net only 3 feet in diameter. A case is also quoted where aphids which feed on conifers were found lying on snow in Spitzbergen, 800 miles from their nearest food supply.

It is pointed out that it is doubtful if the movement of a crop from one area to another within any distance less than a few miles is of any value in the control of the majority of insect pests. The possibility of exterminating an insect pest becomes untenable unless it can be done over the whole area of distribution; and the problem of keeping an area free from virus infection certainly appears more difficult in view of the vast journeys that aphids are now known to make. Finally, the author, whilst acknowledging that much inspection work has been of undoubted value, cannot forbear to draw attention to the millions of insects per square mile drifting over the heads of the inspectors engaged in their work.

The Wheat Blossom Midges. H. F. Barnes. *New Biol.*, No. 14, 3-24.

A full account of these interesting and important pests of wheat is written in a popular form. The work described is leading, in particular, to the possible prediction of outbreaks ; it is stated that the next is expected in 1955 or 1956. So far, the work suggests a five-year cycle. Prediction of future abundance of such pests becomes a difficult problem when the midges appearing in any one year are not derived exclusively from the larvae which were in the ears during the previous year. The emerging midges may consist of a mixture of individuals from the previous three or four years, or even from as far back as twelve years. The midges have a habit of resting before emergence, to which the term " diapause " has been given.

Spray Treatments for Control of Woolly Aphis (Eriosoma lanigerum) on Apple Trees. G. G. Taylor. *N.Z. J. Sci. Tech.*, 1952, **34,** 258-63.

An account is given of experiments in the control of Woolly aphid by means of BHC, DDT and other sprays, and of the effects of these sprays on the Woolly aphid parasite (*Aphelinus mali*).

BHC gave a high degree of control when used as a dormant and a summer spray. When technical BHC was used in the summer, tainting of the fruit occurred, but BHC containing 99 per cent of the gamma-isomer gave no tainting, even when applied three weeks before the picking of the fruit.

DDT sprays did not affect Woolly aphid, but were highly toxic to the parasite (*A. mali*) ; as a result, DDT spraying resulted in increased populations of Woolly aphid. BHC was also toxic to the parasite.

Parathion sprays gave a partial control of Woolly aphid.

Hot-Water Treatment of Strawberry Runners. L. N. Staniland. *Plant Pathology*, 1953, **2,** 44-8.

This paper describes the determination of the rate of penetration of heat into the tissues of strawberry runners, using an electrical method, and also the method for determining the time required to kill eelworms at various temperatures. Field trials with treated runners are also described, and it is shown that a treatment of 7 minutes at 115° F., followed by a cold water plunge, gives complete control of Stem and Bulb eelworm (*Ditylenchus dipsaci*) in strawberry runners. This shortened treatment at a higher temperature overcomes the drawbacks found in the past to the treatment of runners.

To obtain complete control of the more common strawberry eelworms (*Aphelenchoides* spp.), it is necessary to increase the length of the treatment to 10 minutes.

The making of a simple and improved hot-water bath is also described.

L.N.S.

VIROLOGY

Lettuce Mosaic. P. R. Fry, *N.Z. J. Sci. Tech.*, 1952, **33,** 52-63.

Lettuce Mosaic is widespread in New Zealand. Infection at the seedling stage caused a reduction in crop weight of 51.6 per cent. Seed from infected plants was between 6 and 15 per cent infected, and commercial seed had 2-3 per cent infection.

Die Bedeutung des Tabakmosaikvirus und des Kartoffel-X-Virus fur den Tomatenanbau. H. A. Uschdraweit. *Angew. Bot.*, 1952, **26,** 118-29.

This is an account of a survey undertaken to examine the losses caused to the tomato industry by tobacco mosaic virus, potato virus X, and the two together (double virus streak). The greatest losses were caused, as would be expected, by the two viruses acting together. In England, however, this double disease is rare in tomato glasshouses. A number of brands of cigarettes were examined for their tobacco mosaic virus content, and about half were found to be infected, particularly Virginia ; cigars and pipe tobacco were also heavily infected. The strain of tobacco mosaic virus which occurs on tomatoes in commercial houses is one which gives local lesions only on *Nicotiana sylvestris*, whereas the cigarettes and cigars contained this strain and one which becomes systemic in *Nicotiana sylvestris* without the formation of local lesions.

The author concluded that all strains of tobacco mosaic caused considerable loss in tomato production.

Contrôle de vira-cabeça do Tomate pela destruiçâo do vetor. A. S. Costa, R. Forster and G. Fraga. *Bragantia*, 1950, **10,** 1-9.

Some experiments were made to control the Tomato Spotted Wilt disease in Sao Paulo, Brazil, by the destruction of the thrips vector. The best results were obtained with a preparation similar to parathion, containing 5 per cent p-nitrophenyl diethyl thionphosphate. Next in efficiency came hexason 2540 M, which is a mixture of BHC with 2 per cent gamma-isomer, 5 per cent DDT and 40 per cent wettable sulphur.

Tomato Spotted Wilt : Control with DDT Sprays. G. Pasfield. *Agric. Gaz. N.S.W.*, 1952, **63,** 138-44.

Spraying three times a week with DDT gave better control of Tomato Spotted Wilt than once or twice a week. Under local conditions in Sydney, spraying at least twice a week is desirable for early tomato crops, with more frequent application if it is practicable. Observations suggest that *Thrips tabaci* is the only species transmitting the virus in Sydney.

A Tobacco Necrosis Virus Associated with Strawberry Plants. J. P. Fulton. *Plant. Dis. Reptr*, 1952, **36,** 313-4.

A tobacco necrosis virus was obtained from the roots of *Fragaria vesca* (East Malling clone), from apparently healthy East Malling clone plants,

and from Blakemore plants which had been grafted to them. The virus gave characteristic local lesions without systemic infection on cowpeas, French beans, tobacco, cucumber, maize and oats. The thermal inactivation point was above 80° C.

It seems as if the host range of tobacco necrosis viruses is being extended. In addition to causing serious damage to French beans in Holland, and to tulips in many countries, it has now been found on *Primula obconica* and carnations.

A Virus Disease of Cocksfoot. Kenneth M. Smith. *Plant Pathology*, 1952, **1**, 118.

A new virus affecting cocksfoot (*Dactylis glomerata*) is recorded. The virus is sap-transmissible and the insect vectors are the aphids *Myzus persicae* and *Macrosiphum euphorbiae*. The symptoms consist of a longitudinal striping of the leaves without distortion or apparent reduction of seed ; the virus has only been transmitted to cocksfoot. The name " Cocksfoot Streak " is proposed for the disease.

This is the first record of a virus disease of the Gramineae in Western Europe, other than the infection of maize with cucumber mosaic virus.

A Virus Disease of China Aster. F.W.A. *Gdnrs' Chron.*, 1952, **132**, 214.

A number of Giant China asters (*Callistephus chinensis*), raised from seed, showed marked distortion of the blooms following an attack by the aphid *Brachycaudus helichrysi*. The leaves showed a marked yellow mottling and the plants were reduced in height. Most of the blooms developed only a few tufts of short, thin florets at the outside, the central ones remaining hard, quilled, and green. The virus was identified as that of Chrysanthemum Mosaic.

(This virus has a very wide host range, and at Cambridge it has been transmitted experimentally to nasturtium (*Tropaeolum*), *Phlox drummondii*, zinnia, helichrysum, wallflower, *Primula sinensis stellata*, lettuce and soya bean.)

Latency in Viruses and the Production of New Virus Diseases. Kenneth M. Smith. *Biol. Rev.*, 1952, **27**, 347.

An account is given, among others, of the newly-described latent virus in sugar beet. Its origin and possible methods of spread are discussed. It is pointed out that there is a little circumstantial evidence for the endogenous origin of certain of the plant viruses, but there may also be some special factors concerning them—notably their methods of spread—of which we are at present ignorant.

K.M.S.

COMMONWEALTH AGRICULTURAL BUREAUX PUBLICATIONS

Mycological Institute

Introduction to the Taxonomy and Nomenclature of Fungi. G. R. Bisby, 1953, 10s. This second edition contains a new part devoted to notes on classification, with an outline of the major fungus groups.

Catalogue of the Culture Collection of the Commonwealth Mycological Institute. 1953, 2s. 6d. The catalogue lists approximately 1,500 cultures maintained at the Institute and available to clients.

Bureau of Agricultural Parasitology (Helminthology)

The Cyst-forming Species of Heterodera. Mary T. Franklin, 1951, 18s. 6d. In this volume Dr. Franklin describes the morphological characteristics, diagnosis and life history of the various cyst-forming eelworms of the genus *Heterodera*. She discusses the role of weeds in their propagation and survival in the soil, and the symptoms and other effects shown by infected plants. Chemical, cultural and practical control measures are suggested.

Bureau of Animal Nutrition

Nutrition Abstracts and Reviews. Recent reviews of interest to the advisory officer are " The Fluorine Problem in Animal Nutrition " (risk of industrial gases, dusts and effluents in this country ; practically no natural hazard) ; " Vitamin E in the Nutrition of Farm Animals " (deficiency apparently more common than has been known) ; and " Helminth-Host Relationship " (an association exists with certain poor diets, but more work is needed).

The report on " The Efficiency of Farm Animals in the Conversion of Feedingstuffs to Food for Man " has been reissued with an addendum which deals with some practical issues ; in mimeograph, price 5s.

Bureau of Horticulture and Plantation Crops

Sand and Water Culture Methods used in the Study of Plant Nutrition. E. J. Hewitt, 1952, 42s. This book describes the methods devised to study the growth and mineral nutrition of plants in controlled cultures. The information compiled and the techniques described will make it a standard guide and reference work for many years to come.

Field Experimentation with Fruit Trees and other Perennial Plants. S. C. Pearce, 1953, 10s. A clear account of recent developments in the layout of field experiments with perennial crops, which should be as valuable to the student as to the investigator.

Bureau of Dairy Science

Although **Dairy Science Abstracts** has been published for fifteen years, it was only two years ago that it became a monthly journal and included a review article on some specialized aspect of dairying. These review articles have been much appreciated by the busy dairy scientist as they enable him to keep up to date on branches of the subject in which he may not be a specialist.

Articles of particular interest to N.A.A.S. officers are No. 3, " Grassland Evaluation in Terms of Milk Production " ; No. 6, " Some Impressions of Dairy Husbandry and Milk Production in the United States"; No. 10, " Rejection Tests for Raw Milk " ; No. 12, " Variations in the Solids-not-Fat Fraction of Milk " ; and No. 18, " Recent Dairy Research in the Netherlands : I. Dairy Husbandry ". Other articles include surveys of recent dairy research and technology in Scandinavia, Australia, Canada, the Mediterranean countries, Switzerland and New Zealand.

PROVINCIAL NOTE

LEY FARMING ON THE KEUPER MARL

J. W. Patterson and W. B. Mercer

National Agricultural Advisory Service, West Midland Province

There is no reliable experimental evidence of the superiority of the rotational system of farming over the two-compartment system ; a change from one to the other is still in some degree an act of faith. The ley affects the whole plan and organization of farming, and its different aspects appeal to different men in different ways. Perhaps its appeal is greatest at the two extremes of soil texture : on light land as a means of combatting drought ; and on heavy land as a means of controlling stickiness, thereby easing the task of cultivation and increasing the growing period of crops.

Experiment is not, however, the only method of achieving progress ; something can be done by piecing together evidence from farms on which the method of management has changed. Such evidence is necessarily bitty. Records and returns made in the ordinary course of farming seem burdensome to the farmer who has to make them, but woefully inadequate to the student seeking the lessons of history. Useful information of this type comes from some of the Keuper Marl areas in Worcestershire. The bulk of the county is covered by soils of great natural fertility, but there are quite a few parts with Keuper Marl and overlying clays, where

flatness and varying degrees of neglect in days gone by combine to produce land difficult to manage efficiently.

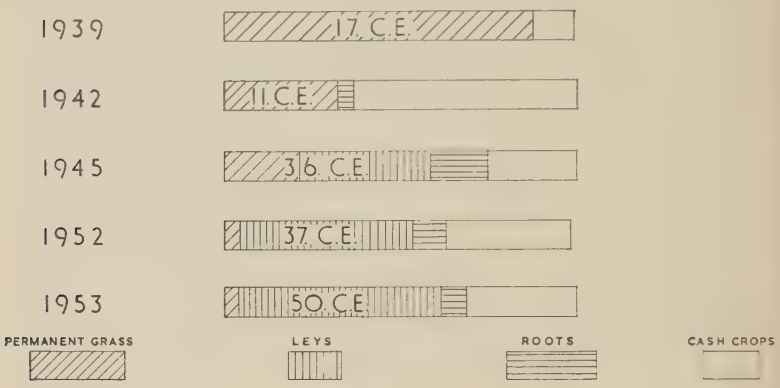
On land of this kind, great extremes were to be found in 1939. Many farms were managed quite productively as grass holdings carrying one beast to two acres or a little more, while on neglected or indifferently managed farms the carrying capacity was as low as four acres or more per beast. Yet the potentialities of the land were great. Land carrying only one beast to four acres could often be converted into 30 cwt. wheat land by the simple act of ploughing. In the war years, ploughing had to be done and wheat grown perforce on all farms. On the more difficult farms the natural tendency was to concentrate on the least difficult fields, and towards 1945 occupiers found themselves with their worst fields still in permanent grass and their better in plough land from which the sod had disappeared. Cultivation was perpetually difficult and crops were poor—wheat yields often fell to 12-14 cwt. per acre. (The differences between neighbouring fields today are often staggering ; we have this year seen crops on recently ploughed turf with yields estimated to be not less than 2 tons per acre, growing alongside crops on old tilled land which it would be charitable to put at 15 cwt. per acre.) Since the end of the war, progressive men have naturally turned to the idea of laying away the old arable land and breaking up fresh ground.

Changed System of Management on Four Farms

To give some precision to this account of changes during the past decade, it is appropriate to cite actual figures from a number of holdings. By chance they are all of medium size, that is, 100-200 acres, but for the purposes of this article the records have been reduced to terms of 100-acre holdings. In no case is the tale quite straightforward. Sometimes occupiers have changed ; nearly always improvements have been effected as they could be managed, rather than in the order theoretically desirable. First things ought to come first : if land is wet it needs draining before crops are grown ; so with hedges, ditches, gates and buildings. All too often on farms in a low condition everything needs doing at once ; it is often necessary to leave fields and premises as they are for the time being, and to carry out drastic improvements when time and capital are available.

Farm A. This is a wet farm, lying in rolling country with many spinneys and wooded pit-holes, belts of rushes and rough marshy places. In 1940, when it was bought by the present owner, some of the pastures were dotted with bushes. The buildings were, however, good, with extensive feeding yards which adapted fairly easily for a " yard and parlour " milking herd. Although a few main drains have been put in, chief reliance has been placed on subsoiling with a single tine implement to a depth of eighteen inches at 4-foot intervals. Development has been expedited by the fact that the occupier held other farms and could call in the old to redress the balance of the new, but apart from some grazing, there are no records of the borrowing of fodder, and the farm has kept its own stock from the outset.

The main plank in development has been the ploughing out of old turf and gradual replacement by leys. Its history can be diagrammatically summarized as follows :



For the first few years, the ploughed-out turf was used mainly for bread grains, and the stock was chiefly store cattle and sheep ; as the fodder area rose again, an attested herd was established. Latterly, the leys have been heavily manured, using 4 cwt. sulphate of ammonia, 3 cwt. superphosphate, and $\frac{3}{4}$ cwt. muriate of potash per acre. Seeds mixtures are of the modified Cockle Park type, and strip-grazing has been successfully practised. Cereal crops have been good, 35 cwt. of winter wheat being common, and beans have also yielded well. The farm, however, remains wet. Winter carting of silage from the pits is difficult, and strip-grazing of kale is often a messy business.

Farm B. The second farm was in many ways an unattractive holding, for the natural wetness of the fields was accentuated by their flatness. In 1939 it carried only one cow-equivalent to $4\frac{1}{2}$ acres of grass and fodder crops, although buildings were fairly extensive. It has changed hands twice since 1939, and the record is of interest as showing some continuity of treatment despite changes of occupier. The present occupier has held it since 1948. A summary of the crop and stock records is given below :

	1939	1947	1950	1952	1953
	acres	*acres*	*acres*	*acres*	*acres*
Wheat, etc.	6	14	34	24	16
Other tillage	10	25	26	36	42
Leys	—	8	5	20	27
Permanent grass	84	53	35	20	15
Fodder acreage per cow-equivalent	4.5	4.5	3.1	2.7	2.5

Here the effect of war-time ploughing is well illustrated. But the figures tell only part of the tale, for at the end of the war the arable fields

were in a poor condition, many of them being foul with buttercups; crops were only moderate and Take-all was prevalent. Moreover, the increase in carrying capacity has been due partly to the use of phosphates and close grazing on the old turf. Inspection of land so treated inevitably raises the question "why plough?" The answer appears to lie in the limited bulk of herbage that can be grown from old turf; on this farm the old grass simply will not carry the same number of stock as the leys.

Seeding down really worn out tillage has proved by no means a simple proposition: when the soil structure has got very bad, the land poaches easily and bakes readily. To establish a ley satisfactorily, large quantities of fertilizer have to be applied at short intervals, certainly at least twice a year during the first two years. The fertilizers used on this farm were 8 cwt. concentrated complete fertilizer and 8 cwt. "Nitro-Chalk" per acre during the first two years.

Farm C. By all ordinary standards this farm would be considered to be better than Farms A and B. In pre-war days it was mainly grass, carrying a reasonably big stock of dairy cattle, and it is now a very attractive holding. As some land has been sold since 1939, it is difficult to calculate accurately the changes in stock-carrying capacity. However, they may be assessed from the fact that in 1943 (when 30 per cent of the farm was under the plough), the fodder acreage per cow-equivalent was 3.3, whereas by 1952 this figure had been reduced to 2.0 acres, whilst milk output has risen from 7,000 gallons in 1943 to 20,000 gallons in 1953.

The progress in conversion is shown by the following:

	1943	1946	1952	1953
	acres	*acres*	*acres*	*acres*
Tillage	30	35	42	45
Ley	—	15	30	30
Permanent grass	70	50	28	25

This particular farm illustrates the psychological effect of ley farming. Farm improvement is an involved business in which one action leads on to another: the ley focuses attention on basic faults like drainage; it encourages a greater use of fertilizers and the keeping of more stock. In this instance, it led to conversion to T.T., and a very considerable improvement in breeding policy which greatly increased the output per cow. Moreover, the ploughed-out land grew cereals, which have helped to maintain a flock of 2,600 accredited poultry. Whilst it is obvious that the farming level of any one year must be determined by the work of that year, the ultimate level depends on the plans of the farmer; few subjects on the farm involve a wider range of thought than the ley, from primary conception to final disposal. This particular farmer is firmly convinced that the improved output has come from a greater use of fertilizers, but really the origin was the ploughing-out of old turf.

FARM D. In 1939, on this, the poorest of the four farms, there were 5 acres of wheat; the remaining 95 acres supported the equivalent of 13 cows. It came into the hands of the present tenant in 1941, and he has found reclamation very difficult. As yet little drainage has been done. The cropping history is :

	1939	1943	1946	1949	1952	1953
	acres	*acres*	*acres*	*acres*	*acres*	*acres*
Wheat, etc.	5	20	21	11	12	9
Other tillage	—	19	23	19	32	34
Ley	—	14	22	38	24	25
Permanent grass ...	95	47	34	32	32	32
Cow-equivalents ...	13	15	31	28	47	50
Milk sales (gallons) ...	—	—	9,900	—	13,800	17,800

An attested herd was established in 1945, and since then the milk sales have gone steadily up. Despite the wetness of the farm, sheep have been especially successful, although the main source of income has been the attested herd. Lucerne has been introduced with much success, and silage-making has replaced root growing. Beans have usually done well.

Although stock-carrying capacity has been brought up to a standard which bears comparison with most farms in the area, it is probable that the rate of improvement could have been increased had fertilizers been used more freely. Subsoiling has now been adopted as a regular farm practice, and this has made the working of the land in spring much easier and has made some pastures very much drier.

Variable as the circumstances on the four farms are, their histories are at least consistent in showing increases in stock-carrying power with the conversion of the permanent grass to ley. The increased cow-equivalents on the farms give only a partial picture of this improved capacity. Before the war the grassland was, in many cases, little better than an exercising ground for the stock, and much of the production, whether as meat or milk, came from purchased concentrates. Today, all these holdings are making high quality silage. Most of the production is from the farms themselves, as sales of cereals exceed purchases of concentrates.

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Edited by

E. C. R. REEVE, B.A., Ph.D.,
and Professor C. H. WADDINGTON, Sc.D., F.R.S.

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